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Efficacy of an Online Resource for Teaching Interpersonal Problem Solving Skills to Women Graduate Students in Engineering

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ABSTRACT

Interpersonal problem solving skills allow engineers to prevent interpersonal difficulties more effectively and to manage conflict, both of which are critical to successful participation on teams. This research provides evidence that the *CareerWISE* online learning environment can improve those skills among women in engineering graduate programs. In a randomized controlled trial, N = 128 female doctoral students were randomly assigned to treatment and wait-list control (WLC) groups; treatment consisted of interacting for at least five hours with an online learning environment with comprehensive instruction in problem-solving applied to common interpersonal situations in the academy. A scenario-based assessment instrument measured participants' ability to describe how they would apply that problem solving to a fictional scenario, and a rubric was used to score the responses. Results showed that treatment group members had better knowledge of interpersonal problem solving steps and were better able to describe how they would apply problem-solving skills to a relevant scenario.

Key Words: interpersonal problem solving; online learning environment; women graduate students



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INTRODUCTION

Broadly defined, problem solving is a process that both identifies multiple alternatives for addressing a problematic situation and facilitates the selection of the option most likely to be effective from among the alternatives (D’Zurilla and Godfried 1971). Across disciplinary perspectives and application areas, it is considered a higher order cognitive skill, requiring more than factual recall or the application of a single component of knowledge or skill. For example, the two highest levels of Bloom’s (1956) well-known taxonomy of cognitive skills deal with the ability to apply knowledge and skills to new domains and are often grouped together under the label of “problem solving” (Crooks 1988). In the field of cognitive informatics, which combines ideas from cognitive science and informatics to investigate the human mind and its relation to associated engineering applications, problem solving is considered to be at the highest cognitive layer of the brain (Wang and Chiew 2010).

In engineering, problem solving is widely regarded as a skill necessary for adequate career preparation (e.g., Clough 2004; National Research Council 2007). The majority of related work within the engineering education community focuses on the application of discipline specific skills to address technical problems (for recent examples, see Liberatore, Vestal, and Herring, 2012; Moreno, Ozogul, and Reisslein 2011; Steif, Lobue, Kara, and Fay 2010). However, the development of effective *interpersonal* problem solving skills is also of great importance (Bancino and Zevalkink 2007; Shuman, Besterfield-Sacre, and McGourty 2005). Such skills allow more effective prevention and resolution of interpersonal difficulties. Among graduate students in particular, they also allow students to manage natural conflicts that can arise, for example, through participation in research teams or interactions with academic advisors (Bernstein 2011).

Despite the importance of problem-solving strategies for addressing interpersonal challenges, effective and easily accessible strategies are not available for teaching and learning them. Recent work also indicates that faculty are uncertain about how to best teach these and other professional skills (Matusovich et al. 2012). One way to increase accessibility is to make content available in an online format, with which students are increasingly comfortable; in fact, the number of students taking at least one online course in the United States has now approached 6.7 million (Allen & Seaman, 2013). The online format makes it possible to appeal to different learning styles with diverse formats through which instructional content can be presented and through which learners can interact (Narciss, Proske, and Koerndle 2007).

While recent years have shown a rise in the development, study, and usage of online environments and simulations to teach technical skills (e.g., Physics Education Technology Project; Perkins et al. 2006; Wieman, Adams, and Perkins 2008), research into the use of online tools for teaching and



learning non-technical or non-procedural skills has been limited. While not developed for engineering students in particular, examples of efforts to teach professional skills in an online format have included the application of web-based immersive technology in preparing salespeople (Kass, Burke, Blevins, and Williamson 1994), advancing medical education, and training members of the military services in interpersonal leadership behaviors and cross-cultural awareness and communication skills (Campbell et al. 2011; Johnson 2010; Zbylut et al. 2007; Zbylut and Ward 2004). The purpose of this paper is to empirically investigate the effectiveness of the *CareerWISE* online learning environment targeting women in doctoral programs in the physical sciences and engineering and designed to positively affect interpersonal problem solving skills.

Women who begin science, technology, engineering, and math (STEM) doctoral programs have already demonstrated their academic abilities and commitment to STEM careers. However, Bernstein (2011) and Bernstein and Russo (2008) suggest that, even so, some women still decide to change course and leave their PhD programs due to discouragement they experience while enrolled in their doctoral programs. While institutional change efforts through programs like the NSF's ADVANCE program, which funds efforts to address aspects of academic culture and institutional structure that may differentially affect STEM women, are critical for improving the policies, practices, and environment for promoting gender equity, the *CareerWISE* online learning environment utilized in the study here takes a complementary approach, working to bolster personal resilience skills, including interpersonal problem-solving skills, and prepare women for the moments when they experience doubts. Notably, the focus on skill building amongst the women who utilize the resource in this study is not meant to imply that the women are deficient or that the difficulties they encounter within their academic environments are of their own making. In fact, a substantial portion of the training used in this study focuses on understanding the gendered and contextual aspects of a problematic situation.

Results are presented from a randomized controlled trial (RCT) in which the intervention was interaction with the *CareerWISE* online resilience training program (<https://careerwise.asu.edu>). The online learning environment used in the study was developed by an interdisciplinary research program at a large public university in the Southwest that works to improve retention in STEM fields where women leave doctoral programs at a significantly higher rate than men (Ampaw and Jaeger 2012; Council of Graduate Schools 2008; Lott, Gardner, and Powers 2009). Study results are presented regarding the participants' ability to describe both an appropriate process for interpersonal problem solving and how that process would be applied to a given scenario relevant to graduate students in engineering. The measurement instrument used in the study is discussed, along with the associated rubrics for evaluating responses and evidence to support the reliability and validity of the rubrics.



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METHODS

Intervention Description

The *CareerWISE* online learning environment utilized in this study is grounded in psychological theory and research on personal resilience and coping (Carver et al. 1989; Lazarus 1993; Lazarus and Folkman 1984; Maddi 2005; Masten 2001), self-efficacy and social-cognitive career theories (Bandura 1986; Bandura 1997; Hackett and Betz 1981; Lent et al. 1994; Lent et al. 2000), and problem-solving processes and cognitive-behavioral interventions (Beck 1983; Pretzer and Beck 2007; D'Zurilla and Nezu 2008). The theoretical grounding for the online learning environment is detailed in Bernstein (2011). Throughout, *CareerWISE* content includes examples relevant to the target audience, drawn from the results of focus groups (Bernstein and Russo 2008) and individual interviews (Anderson-Rowland et al. 2007) as well as research on women's experiences in science and engineering fields (Etzkowitz et al. 2000; Fox 2001; Preston 2004; Rosser 2004, 2012; Sonnert and Holton 1995; Valian 1998, 2007; Settles et al. 2006; Seymour and Hewitt 1997; Xie and Shauman 2003; Wao et al. 2010).

CareerWISE offers skill building around four areas found to be of common concern amongst the target audience (Bernstein and Russo 2008): handling difficult interactions with an advisor, juggling academic and personal commitments, navigating a climate that can be unfriendly to women and managing delays and setbacks that are common in the course of pursuing research. There are more than 250 content pieces in the online program, including over 160 video clips, 3 to 8-minutes in length, taken from interviews with women with STEM doctoral degrees about their experiences in graduate school and how they coped; over 50 informational and instructional modules on topics such as habits of thinking and self-talk, interpersonal communication styles, staying positive, expectations for and from an advisor, and recognizing sexism; self-tests and practice exercises; and links to other relevant professional organization and resources.

Although the training has many related learning objectives that are theoretically and empirically predictive of persistence to degree completion (Bernstein 2011), one of the key learning goals is to positively affect the online program visitors' ability to apply interpersonal problem solving skills. STEM graduate students are generally very familiar with problem solving models (e.g., the engineering design process), but they may not be familiar with how to apply such tools to handle non-technical situations that arise, for example, as a normal part of research team participation. As such, the *CareerWISE* learning environment focuses on the development of skills (e.g., considering others' perspectives, managing emotional responses, and appropriately identifying stakeholders) needed to apply a problem-solving model to manage such interpersonal situations. The specific steps and sub-steps taught by the *CareerWISE* learning environment to manage interpersonal problems are shown in Table 1, along with an example of associated content for each of the steps.



Step	Sub-steps	Example <i>CareerWISE</i> Content
Step 1: Assess the problem	Step 1A: List the facts	Skill Module: learn how to recognize what sets off your stress reactions and how these triggers influence your interactions with your environment
	Step 1B: Understand yourself	
	Step 1C: Understand the context	
	Step 1D: Collect missing information	
Step 2: Specify the outcome you want	Step 2A: Select your priority problem	Skill Module: Learn how to turn ambiguous goals or problems into attainable objectives
	Step 2B: Establish what's under your control	
	Step 2C: Set a concrete outcome	
Step 3: Strategize	Step 3A: Identify potential solution strategies	Skill Module: learn how to identify and build on your cognitive and emotional strengths
	Step 3B: Assess your skills	
	Step 3C: Weigh strategies and select the best one	
	Step 3D: Make a plan	
Step 4: Execute and evaluate	Step 4A: Act on your plan	Video clips from interviews with successful STEM women appear throughout the online program. Sample topics include the following: 1. Persuading an advisor 2. Isolation and a proactive solution
	Step 4B: Evaluate whether the desired outcome was achieved	
	Step 4C: Cycle back to Step 1 if the outcome was not achieved	
	Step 4D: Review what you have learned	

Table 1. *CareerWISE's* problem solving model. The two left columns of this table originally appeared in Bernstein (2011).

Instrumentation

Research shows that skills requiring higher order thinking are most appropriately assessed using open-ended performance based instruments (Jonsson and Svingy 2007; Sankar, Varma, and Raju 2008). Moreover, assessments providing learners the opportunity to respond to realistic scenarios are particularly useful for the measurement of learning objectives that are difficult to measure with more traditional formats (e.g., Jonsson and Svingy 2007; Kranov et al. 2008; McMartin, McKenna, and Youssefi 2000). A drawback of such assessments is that they typically require the development of an effective scoring rubric for the evaluation of learner responses and the associated training of scorers who can apply the rubric reliably. An alternative, less labor-intensive assessment approach for such skill-based measurements would be to ask for participants to self-report their abilities, but such reports are typically inflated (e.g., Arlin 1976).

Since the goal of the study was to evaluate whether an online learning environment could positively affect participant ability to describe how they would apply interpersonal problem solving skills, an assessment approach was called for beyond what self-report data from rating scales can provide. Consequently, an open-ended, scenario based assessment was chosen, the benefits of



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APSS Item Number	Prompt
Question 1	List the generic steps you would use to tackle a personal or interpersonal problem. The steps need not be put in the context of any specific scenario.
Question 2	Imagine you are [main character from scenario's name here]. How would you apply the steps and sub-steps you listed in Question 1? Please provide as much detail as possible with your response, and remember to consider that YOU are [main character from scenario's name here] in the situation (e.g., we are not asking you to give advice to [main character from scenario's name here]).

Table 2. Prompts for each of the APSS Questions.

which heavily outweighed the resource-related drawbacks. We discuss later the process that was followed for rubric development and the resulting measures of the rubric's effectiveness.

The Assessment of Problem Solving Skills (APSS) instrument contains two questions. The first asks the respondent to list the steps taught by the *CareerWISE* learning environment to tackle interpersonal problems, and the second, designed as a performance assessment, asks participants to describe how they would *apply* interpersonal problem solving skills to a realistic graduate student-based scenario. Two versions, A and B, of the assessment were developed, each presenting a different scenario. The exact prompts for each of the two items are shown in Table 2.

The context for the scenarios used in Question 2 of each version of the APSS were derived from focus groups conducted with members of the target population (Bernstein and Russo 2008). The scenarios themselves were written by an interdisciplinary team of graduate students and faculty including members from the fields of industrial engineering, bioengineering, physics, and biology (Bekki et al. 2008). In the writing process, attention was paid to ensure the relevance of scenarios across multiple disciplines. Each scenario was also reviewed for content validity by two STEM faculty members who were not on the writing team and then revised accordingly. In the scenario presented in Version A of the APSS, the main character struggles to get timely feedback from her advisor on her research. In the scenario presented in Version B of the APSS, a student's graduation plans are in jeopardy because she needs the signature of her absent advisor in order to schedule her dissertation defense.

Participant Recruitment and Demographics

Participants for the RCT were recruited from STEM doctoral programs nationwide and included female students in at least the second year of their doctoral studies. First year doctoral students were excluded from the study because they were less likely to have begun engagement with a research group. Specifically, women were recruited from the following fields in which women are typically most underrepresented: chemical engineering, civil engineering, electrical engineering, materials science, mechanical engineering, computer science, physics, applied physics, math, applied math, chemistry, astronomy, and geological sciences.



University Names	
Carnegie Mellon	Georgia Institute of Technology
MIT	Northwestern
Purdue	Rutgers
Texas A and M	UC Davis
UCLA	University of Arizona
University of CA – Berkeley	University of Central Florida
University of Cincinnati	University of Colorado (Boulder)
University of Illinois Urbana-Champaign	University of Iowa
University of Massachusetts, Amherst	University of Michigan
University of Pittsburgh	University of Southern California
University of Texas Austin	University of Virginia
Virginia Tech	

Table 3. Universities from which research participants were recruited.

Recruitment relied on participant self-selection in response to fliers that were distributed electronically and posted at the 23 universities shown in Table 3. These universities were selected because the number of women in the targeted departments was at least 15 at the time of the study. An informational flier, with a request to distribute to female students the invitation to participate, was emailed to relevant department chairs at each of the universities and a follow-up phone call was made to confirm receipt. The recruitment efforts yielded 150 qualified participants, not all of whom were from the target universities; 128 completed the protocol.

Background information about the RCT participants was obtained from a survey that asked standard demographic questions in addition to questions about academic status, career goals, and disciplinary research experiences. The mean age of participants was 27.31 years, and, on average, they had completed 3.91 years of doctoral study. More than half of the participants (57%) came from a science or math discipline, while the remainder (43%) came from engineering disciplines. Of note is that the proportion of participants in the study sample from engineering (vs. non-engineering) very closely matches that in the STEM population at the time of the study. Per National Science Foundation statistics (2004, 2010), 42% of the population of women STEM doctoral students are from engineering and 58% from math and science. Most participants (76.5%) reported English as their primary language, and 85.4% of participants reported their country of origin as the United States, China, India, or Canada. Finally, participants self-identified their race/ethnicity as 3% African American, 17.3% Asian or Pacific Islander, 4.5% Hispanic, 0.8% Native American or Alaska Native, 69.9% Caucasian/White, 2.3% Arab American, and 0.8% multi-ethnic.



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The choice to include the broader STEM population (vs. engineering only) was appropriate given that the nature of the doctoral student experiences is similar between the physical sciences and engineering and that the underrepresentation of women extends beyond engineering to the physical sciences (per the National Science Foundation, 2011, only 34% of doctoral students in the physical science fields are women). Moreover, the choice of the wider population was necessary from a practical perspective, as it increased the size of the population from which the research participants could be drawn.

To further evaluate the appropriateness of drawing conclusions about the engineering students using the STEM sample, the scores of participants who identified themselves as having come from an engineering discipline were statistically compared to those in the sample of participants who identified themselves as being in a science or mathematics degree program. Specifically, on each of the two questions on the APSS, the scores for engineering participants and non-engineering participants were compared using a one-way ANOVA. For participants who were in the WLC group, scores on the second administration of the APSS (following exposure to the *CareerWISE* online learning environment) were used as the responses in the analysis. As demonstrated by the results presented in Table 4, comparison of the engineering vs. non-engineering participants for both Question 1 ($p = 0.30$) and Question 2 ($p = 0.64$) showed there was no statistical difference between groups. As such, we found it to be appropriate to draw conclusions from the study about engineering students based on data obtained from the entire science and engineering sample.

Protocol

The study followed a wait-list randomized controlled design, which is known to produce the strongest quality of evidence for evaluating an intervention's effectiveness (US Department of Education 2009). In randomized controlled trials (RCTs), participants are randomly divided between treatment and control groups. The treatment group receives the intervention while the control group does not. Following the delivery of the intervention to the treatment group, comparisons are made between the treatment and control groups to measure the effects of the intervention. In the

Question from the APSS	Group	Mean Score	SD	ANOVA p-value
Question 1	Engineering (N = 55)	2.57	0.79	0.303
	Non-Engineering (N = 73)	2.71	0.74	
Question 2	Engineering (N = 55)	24.40	4.47	0.643
	Non-Engineering (N = 73)	24.73	3.34	

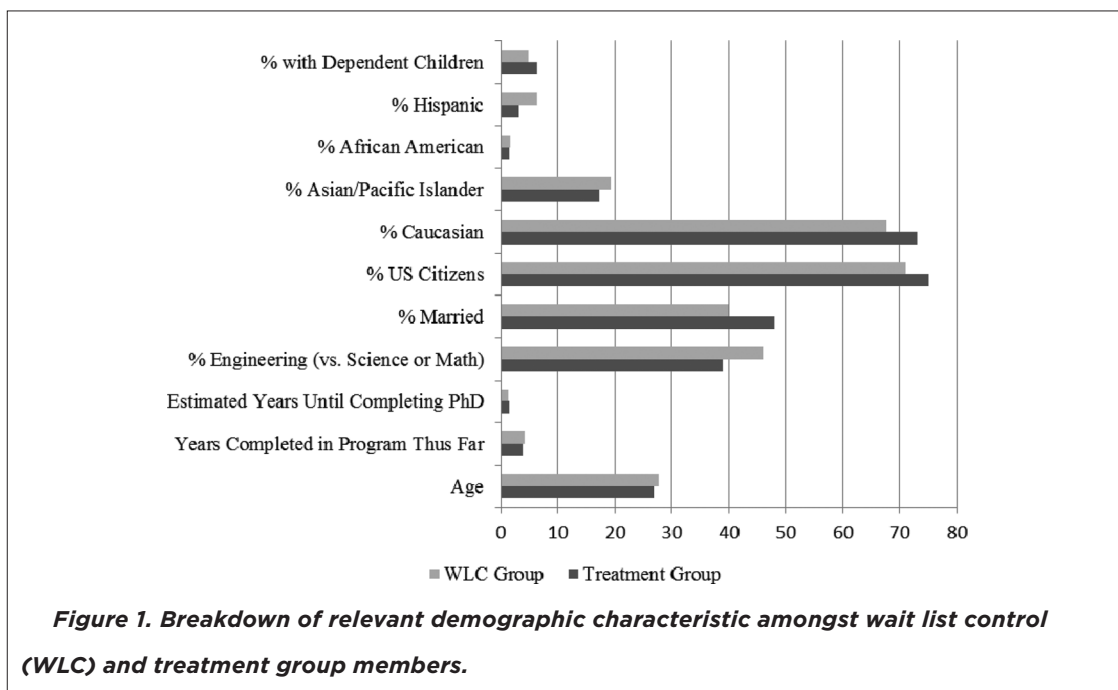
Table 4. Summary of ANOVA analyses comparing engineering and non-engineering participants.



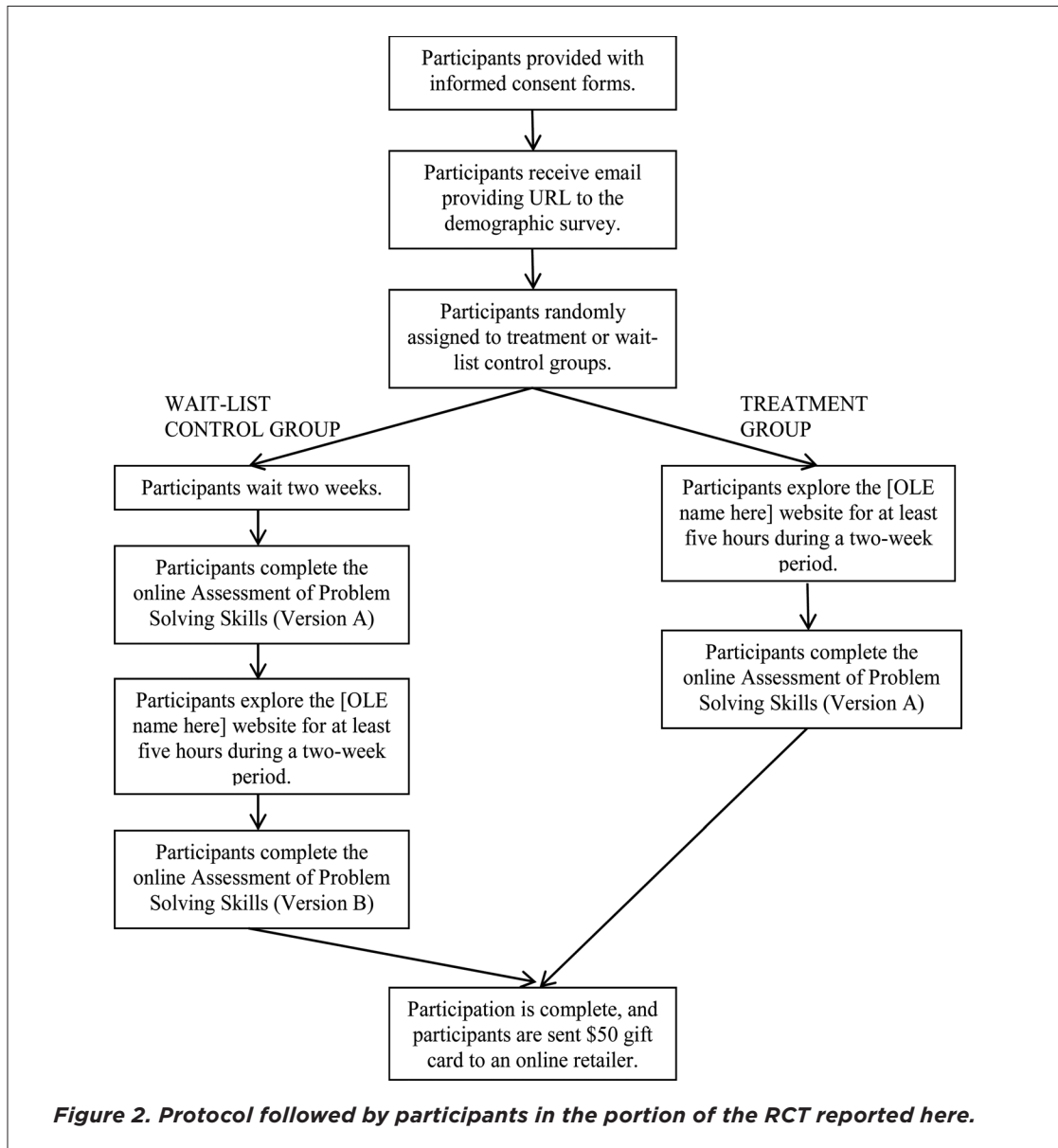
wait-list controlled design employed here, the control group is then given the intervention, which allows those participants to also gain any associated positive impacts.

The data and results reported here add to those previously reported (Bekki, Smith, Bernstein and Harrison 2013) about the efficacy of the *CareerWISE* online learning environment. Measurement of participant learning in the RCT was carried out using two instruments, administered to participants at the same points in the study. The first, made up of seven ratings-type scales, was designed to capture self-report data from participants on learning outcomes such as resilience and coping efficacy. The second instrument was the Assessment of Problem Solving Skills (APSS), which is the source of the data reported here. The protocol, recruiting, and participant demographics are the same that were used in the broader RCT, but the instrumentation presented here is only related to the measurement and assessment of participant's interpersonal problem solving skills, not other learning outcome measures. Further detail on the other outcomes assessed during the RCT can be found in (Bekki, Smith, Bernstein and Harrison 2013).

In total, 128 participants successfully completed the RCT protocol. Figure 2 shows the specific process participants followed during the study. They first completed a demographic survey online and were then randomly assigned to either a wait-list control (WLC) or a treatment group. Of protocol completers, 64 were in the WLC group, and 64 were in the treatment group. Important to the validity of an RCT study is the random assignment of participants to the WLC and treatment groups. Figure 1 illustrates the balance achieved on relevant demographic characteristics generated by this random assignment.



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The treatment group was then given access to the *CareerWISE* online learning environment and asked to spend at least five hours exploring it in an unconstrained manner during a two-week time frame. The unconstrained nature of the exploration meant that participants were directed neither to engage with any particular content in the online learning environment nor to interact with content in any particular order. This choice was made to mimic how the online learning environment would be used outside of the experimental setting and introduced the possibility that research study participants might not visit a representative sample of content. The choice of five hours was made based



on considerations of the amount of content available on the online program; we wanted participants to have the opportunity to cover both the depth and breadth of the material, and we estimated that review of a reasonable proportion of the material would require at least five hours. Also of note is that this study was performed prior to the public release of the online learning environment, so we did not have regular visitor usage patterns available to us from which to generate a treatment length. Although we suspected that in any one visit, a user would spend a shorter amount of time, the online learning environment is designed to have repeated visits over an extended period of time, and this experimental design was intended to mimic this behavior. After completing the *CareerWISE* learning environment exploration, participants were given online access to Version A of the APSS.

WLC group participants were given Version A of the APSS approximately two weeks after they submitted the demographic survey. They were then given access to the *CareerWISE* online learning environment and asked to spend at least five hours interacting with it, in the same unconstrained manner that the treatment group used. After completing their exploration, each WLC group participant was given online access to Version B of the APSS, which had the same format as Version A, but depicted a different scenario to which the participants were asked to respond.

Notably, participants (in both the WLC and treatment groups) were instructed to complete the APSS without referring back to the online learning environment itself. After submission of the APSS (second APSS for the WLC group), participation was considered complete. As compensation for participation, both the WLC and treatment group members who completed the protocol were given continued access to the *CareerWISE* learning environment (not available to the public until five months after data collection was completed) along with a \$50 gift card to a prominent online retailer. Completing participants spent a mean time of 5.39 hours on the online program.

During the RCTs, frequent email communication was maintained with study participants. Reminders were sent for each of the key protocol activities, including survey submissions and online program exploration. For each activity, the final reminder indicated to the participant that she would be dropped from the study if she did not comply within the allotted time period. Participants who did not complete relevant tasks by the final deadline were informed via email that they had been dropped from the study. When participants were dropped from the study, the protocol was reinitiated with a back-up participant. Back-up participants were held to the same protocol as initial participants and were also dropped from the study if they did not complete activities in a timely fashion. In total, 43 participants were dropped from the study after giving their consent to participate. Notably, of the 43 who were dropped, only 19 actually completed the first step in the protocol (submission of the demographic survey). A comparison of demographic data between the 19 participants who dropped out of the study after beginning it and those who completed and those who completed the study did not reveal any notable differences.



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SCORING RUBRIC

In order to evaluate participant responses to the APSS, two scoring rubrics were created based on the *CareerWISE* learning objectives associated with the interpersonal problem solving model shown in Table 1. The first rubric included a coding scheme for scoring responses to Question 1 (identical in both versions of the instrument) of the APSS. The coding scheme measured participant ability to describe the interpersonal problem solving model that formed the basis for *CareerWISE* content. The second rubric, used in scoring Question 2, included 22 coding schemes which measured participants' ability to describe how they would apply the problem solving model to a fictional but realistic scenario. Eleven of the coding schemes for Question 2 were for Version A of the APSS (one for each of the sub-steps contained within the first three steps shown in Table 1), and eleven were corresponding rubrics for Version B of the APSS. There is only a very small amount of specific content on the online program related to Step 4 of the problem solving model. As a result, the research team agreed that it would not be appropriate to score responses related to Step 4 of the problem solving model.

Each of the coding schemes specified scores for participant responses on a four-point scale, and descriptive text was provided for each of the four scoring options to assist raters. Figure 3 gives an example of one of the coding schemes. The coding scheme in Figure 3 is the first draft of the coding scheme used to score responses to Question 2 of the APSS, with regard to problem solving sub-step 3C.

Step 3C: WEIGH strategies and select the best one				
Score	1	2	3	4
	Does not choose a solution strategy.	Selects a solution strategy BUT DOES NOT Describe the pros and cons of potential strategies. AND DOES NOT Provide a description of the final decision making strategy (e.g., "went with my gut") that was used to select the chosen solution	Selects a solution strategy AND Describes the pros and cons of potential strategies. BUT DOES NOT Provide a description of the final decision making strategy (e.g., "went with my gut") that was used to select the chosen solution	Selects a solution strategy AND Describes the pros and cons of potential strategies. AND Provides a description of the final decision making strategy (e.g., "went with my gut") that was used to select the chosen solution

Figure 3. First draft of the rubric used for scoring Question 2, Step 3C, for participant responses to the Assessment of Problem Solving Skills used during the RCT.



Following initial development of the rubrics, a scoring team participated in a rater training led by a counseling psychology faculty member who is an expert in the interpersonal problem solving content. The purpose of the training was to increase rater understanding and skill in applying each of the coding schemes in an effort to optimize inter-rater reliability. Prior to the training session, each team member was provided with and asked to use the rubrics to score a selected set of responses. During the training session, the raters compared scores to each response and discussed their reasons for assigning the score based on the rubric, with the goal of reaching consensus on the correct score for each participant response.

Based on the discussions during the training session and on evaluation by an expert in interpersonal problem solving, refinements and improvements to the rubrics were incorporated. An example of the final coding scheme used to score responses to Question 2 of the APSS, with regard to problem solving step 3C (the draft coding scheme for this same step was provided earlier), is shown in Figure 4.

Step 3C: WEIGH strategies and select the best one				
Score	1	2	3	4
Descriptive	Does not choose a solution strategy.	One of the following conditions are met: Selects a solution strategy OR Describes the pros and cons of potential strategies. OR Provides a description of the final decision making strategy (e.g., "went with my gut") that was used to select the chosen solution	Two of the following conditions are met: Selects a solution strategy AND/OR Describes the pros and cons of potential strategies. OR Provides a description of the final decision making strategy (e.g., "went with my gut") that was used to select the chosen solution	All of the following conditions are met: Selects a solution strategy AND Describes the pros and cons of potential strategies. AND Provides a description of the final decision making strategy (e.g., "went with my gut") that was used to select the chosen solution

Check box if answer meets each particular criterion:

☐ Selects a solution strategy

☐ Describes the pros and cons of potential strategies.

☐ Provides a description of the final decision making strategy

SCORE, 3C: _____

Figure 4. Example of the final rubric used for scoring question 2, Step 3C, for participant responses to the problem solving assessment used during the RCT.



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Assessment of Rubric Adequacy

Following scorer training, each member of the scoring team used the updated version of the rubrics to score 70 randomly selected responses to Question 1 and 70 randomly selected responses to Question 2. Responses were selected from all available responses to the APSS and so included responses to both Versions A and B of the assessment instrument. Raters were not told whether a response was from a participant in the treatment group or wait list control group, and also could not determine which responses to Question 1 and Question 2 came from the same participant.

The most common way to assess the adequacy of scoring rubrics for open-ended responses is to determine consensus-based inter-rater reliability (Stemler 2004), which measures the degree to which scorers agree on how to assign the various outcomes available according to the rubric. If the consensus inter-rater reliability is high enough for a large enough sample of the data, then scores by multiple scorers are considered equivalent, and only one scorer can rate additional data (vs. having multiple scorers look at 100% of the data). Krippendorff's α (Krippendorff 2004) was used for this calculation. The selection of 70 responses to each question was made based on Krippendorff's (2004, Table 11.2) recommendations for a sample size of at least 70 responses to accurately determine whether $\alpha \geq 0.80$ with a significance level of 0.05 when the rubric has four scoring outcomes.

The inter-rater reliability, α , was calculated separately for Question 1 and Question 2 of the APSS. The score used in the calculation for responses to Question 2 was the sum of the scores across all the sub-steps. We acknowledge that the drawback of summing across all sub-steps is that it takes away the possibility for evaluating the impact of the online learning environment on specific steps/components of the problem solving model. However, participants were allowed to explore the online learning environment in an unconstrained manner during the experimental treatment period, and tracking data collected during the study shows that the number of participants who actually viewed each particular content element (of the hundreds available) within the learning environment is not large enough to perform an analysis at the level of problem solving sub-step.

Using the KALPHA macro in SPSS (Hayes and Krippendorff 2007), a 95% confidence interval surrounding α for each of the questions on the APSS was calculated. The resulting confidence intervals around α for Question 1 were 95% CI [0.48, 0.58] and 95% CI [0.71, 0.81] for Question 2. Krippendorff (2004, p. 241) recommends an α of at least 0.80 for drawing more than tentative conclusions. This value is included in the confidence interval surrounding the α value for Question 2, but is not within the confidence interval generated for Question 1. Also worth noting, however, is that Jonnson and Svingby (2004), who report on the results of an analysis of 75 peer-reviewed journal articles in which rubrics were used to evaluate responses to open-ended assessments, state that the majority of such assessments report a rater consensus of between 55 - 75%. While the reliability of Question 1 does not meet the standards suggested by Krippendorff (2004), the confidence interval surrounding α for



Question 1 does fall within the range reported by Jonnson and Svingby (2004), making it consistent with other published rubrics of this type.

Additional evidence for the adequacy of an assessment tool is demonstrated by its validity, which considers whether the assessment actually measures what it was designed to measure (Moskal, Leydens, and Pavelich 2002). Expert opinion is often used as a measure of content validity (Stemler 2004). As mentioned previously, the APSS was evaluated (and resulting modifications incorporated) by a domain expert before being disseminated to scorers for the scoring of the data used in the reliability calculations. Based on the outcome of the inter-rater reliability and validity evaluations, the scoring rubrics were considered to be appropriate for assessing the knowledge of and scenario-based application of interpersonal problem solving skills.

The final scoring rubrics (available upon request to the authors) were applied in preparing the full data set for analysis. Responses to each question on the APSS not scored previously were divided amongst the trained scorers. Given the inter-rater reliability of the instrument, scoring of a single response by multiple scorers was deemed unnecessary. For data that had previously been scored by multiple scorers, the average score across all original scorers was calculated. Responses to Question 1 and Question 2 were treated as separate responses for analysis. Recall that for Question 2, a separate coding scheme was used to score responses with regard to each sub-step of the problem; in all analyses, the sum of the scores across all sub-steps of the problem solving model was used.

RESULTS

Presented next are the results of analyses conducted based on participant responses to the APSS. The results are based on one-way ANOVAs comparing WLC and treatment group members and paired t-tests showing the change in scores across the two administrations of the APSS to WLC members. They illustrate the effectiveness of the *CareerWISE* online learning environment in positively affecting participant ability to describe an effective interpersonal problem solving model and to describe how they would apply that model to a scenario depicting a common interpersonal challenge. Additional analyses are presented on the correlation between scores on the APSS and length of participant responses and on comparisons between the treatment group and WLC group on the length of responses.

For each of the two responses (corresponding to scores from Question 1 and Question 2 of the APSS), a one-way ANOVA comparing the treatment and wait-list control groups was performed. Additionally, a paired t-test comparing the two administrations of the problem solving assessment to the wait-list control group was performed for each response. Results for significance, associated



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APSS Ques.	Points Possible	Group	Mean	SD	Range (Min, Max)	ANOVA p-value	Effect Size
1	4	Treatment (N = 64)	2.70	0.68	(1, 4)	0.005	0.51
		WLC (N = 64)	2.35	0.71	(1, 4)		
2	44	Treatment (N = 64)	25.16	3.87	(15, 33)	0.001	0.58
		WLC (N = 64)	22.91	3.82	(12, 30)		

Table 5. Summary of ANOVA analyses comparing APSS Scores between treatment and wait-list control groups. Effect sizes were calculated using Cohen's d.

effect sizes are given in Table 5 and Table 6, along with summary statistics for each of these analyses. Effect sizes were calculated using Cohen's d (Cohen 1988) and place the differences between groups in context. The statistical significance of both ANOVA analyses and associated effect sizes provide evidence supporting a conclusion that interpersonal problem solving skills can be taught and that exposure to even a brief intervention designed to affect those skills was able to generate both increased knowledge of the interpersonal problem solving steps and an improved ability by participants to describe how they would apply those skills to a fictional scenario.

The paired t-test results shown in Table 6 compare APSS scores of WLC group participants in the study before and after their exposure to the online learning environment. Results include the mean and standard deviation of WLC participants' scores on the APSS pre and post interaction with the online learning environment. The p-value and effect sizes are presented as the post-treatment administration of the APSS minus the pre-treatment administration. Consequently, for both Question 1 and Question 2, participants were shown to score significantly higher ($p < 0.05$) on the second administration of the assessment.

One of the intentions of the intervention is to move participants away from a problem solving approach that considers only a quick response to a technical problem toward a more thoughtful process that incorporates personal and self-management perspectives. To evaluate the effectiveness

APSS Question	Mean (Pre)	SD (Pre)	Mean (Post)	SD (Post)	p-value	Effect Size
Question 1 (N = 64)	2.35	0.71	2.60	0.84	0.023	0.30
Question 2 (N = 64)	22.91	3.82	24.02	4.10	0.049	0.25

Table 6. Summary of paired-t analyses comparing two administrations of the APSS within the wait-list control group. Results are presented as the difference between the second (post) and first (pre) administrations of the APSS.



with which this goal was achieved, an analysis of participant response length was conducted. First, the correlation between response length and score was determined to be $r = 0.22$ for Question 1 of the APSS and $r = 0.70$ for Question 2, indicating that, particularly for Question 2, longer responses received higher scores. The higher correlation between response length and score for Question 2 was not unexpected, as Question 1 asks participants to simply list steps they would employ in tackling a personal or interpersonal problem. In comparison to technical problem-solving, the sub-steps associated with assessing the problem (see Table 1) include significant detail related to the specific interpersonal aspects of the problem. The second question of the APSS asks participants to consider and report how they would actually apply all the elements of their interpersonal problem solving strategy to a given scenario. Responses that scored higher on this question included more detailed considerations for the specific interpersonal interactions within the scenario.

Finally, given that longer responses were correlated with better scores, an analysis was performed to understand whether the treatment group participants had statistically longer responses than those in the WLC group. A one-way ANOVA was performed comparing the number of words/response for each question. The results of this analysis are given in Table 7. They demonstrate that for Question 2 of the APSS, the participants in the treatment group did have statistically longer responses than participants in the WLC group, providing additional support for the effectiveness of the *CareerWISE* online learning environment.

DISCUSSION

The primary contribution of this paper is to provide empirical evidence in support of the notion that an online learning environment can positively impact the ability to apply the interpersonal problem solving skills fundamental to academic and career life among women engineering doctoral students. Such skills are theoretically linked to persistence amongst women graduate students

APSS Question	Group	Mean (Words/Response)	SD (Words/Response)	ANOVA p-value
1	Treatment (N = 64)	128.81	88.34	0.127
	WLC (N = 64)	105.86	80.47	
2	Treatment (N = 64)	331.2	178.4	0.001
	WLC (N = 64)	228.7	161.9	

Table 7. Summary of ANOVA analyses comparing response lengths (in words/response) between treatment and wait-list control groups.



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(Bernstein 2011), and while researchers have looked at methods to best teach and assess professional skills (see, e.g., Kranov et al. 2008; Goh 2012; Mohan 2010; Shuman, Besterfield-Sacre, and McGourty 2005), engineering faculty remain unclear about how to address these competencies in the classroom (Matusovich et al. 2012). Such a resource, then, would also be useful as an individual resource for graduate students to use when they need or could benefit from it.

Results were presented from a scenario-based assessment of interpersonal problem-solving skills in a randomized controlled trial with a nationwide sample of participants. The rubric used to assess participant responses in the RCT was shown to have sufficient inter-rater reliability and validity. Specifically, a 95% confidence interval around the inter-rater reliability for Question 1 of the scoring rubric was [0.48, 0.58], and for Question 2 was [0.71, 0.81]. We acknowledge we were surprised that Question 1, which is closer to a knowledge-recall type of question than Question 2 (and so might be expected to be easier to score), had a lower inter-rater reliability. We suggest the lower inter-rater reliability is a function of the rubric used to score Question 1, which was largely a function of how closely participants were able to recall and describe specific sub-steps of the interpersonal problem solving model offered in the online learning environment. Many participants offered steps not contained within the model presented in the online learning environment or listed a sub-step without enough detail to determine whether it was correct or not. We suggest that the inter-rater reliability for this question may have been improved if we had structured the prompt to be more focused, for example, by asking participants to list a particular number of sub-steps.

Based on the comparison between treatment and WLC participants, participants in the treatment group were shown to have a statistically superior ability to describe the steps they would use to apply interpersonal problem solving skills ($p < 0.01$). Moreover, and perhaps more importantly given the notion that what one can actually do is more important than what one can recall (Wiggins 1993), participants in the treatment group showed a statistically better ability to show how they would apply their interpersonal problem solving knowledge to a relevant, open ended scenario ($p < 0.01$).

Positive effect sizes (Cohen's d , 0.508 and 0.583 for Questions 1 and 2 respectively) associated with the analysis comparing treatment and wait-list control groups provided additional support for the results. These medium effect sizes (Cohen 1988) compare favorably to other studies in which the application of skills is assessed. For example, in a study designed to measure information literacy using a scenario-based assessment, Katz et al. (2008) reported an effect size of 0.42 (using Cohen's d) when comparing the scores between first year and second year undergraduate students. In a meta-analysis of 40 papers, Gijbels et al. (2005) reported an average effect size of 0.34, computed using Glass's delta, when comparing the impact of a problem based learning pedagogical technique with another technique in the ability to apply relevant knowledge and concepts. Similar results were given by Dochy et al. (2003) who reported in a meta-analysis an average effect size of 0.46, calculated



as the standardized mean difference (d-index) effect size, for the assessment of procedural knowledge when comparing problem based and lecture-based pedagogical styles. Finally, Tsaushu et al. (2012) reported an effect size of 0.24, calculated using Pearson's r , when comparing scores on an open-ended question-based assessment for students being taught with two different pedagogical techniques in a biology class. The effect sizes for the present study present a valuable reference point and support for our results even though we did not compare two alternative treatments as in the cited examples. Worth noting is that a comparison with an alternate treatment was not actually possible in our study, as we are not aware of an available alternative to the treatment used.

A paired t-test analysis comparing the two administrations of the APSS to the WLC group members was also presented. This analysis demonstrated significant improvements on both dimensions (ability to describe appropriate steps and ability to describe how they would apply those skills and steps to solving a relevant interpersonal issue) following exposure to the learning environment. Associated effect sizes from this analysis across both questions, although smaller in magnitude than those for the ANOVA analysis, provide further support for the effectiveness of the *CareerWISE* online learning environment in improving problem solving skills as assessed here.

Finally, it is also worth repeating that participants in the study were allowed to explore the *CareerWISE* learning environment in an unconstrained manner. There was no requirement that participants actually visit all the parts of the resource dedicated to specific instruction on the interpersonal problem solving model. This was a deliberate choice so that the experimental treatment would mirror the way that visitors to the online program would actually interact, searching based on their own interest rather than according to a step-by-step instruction. While all the content on *CareerWISE* relates at least indirectly to one or more of the steps suggested for interpersonal problems, only six (of hundreds of) pages on the online program explicitly introduce, describe one of the steps, or provide a quick overview of the steps themselves. These pages are highlighted on the front page of the *CareerWISE* online learning environment in an effort to direct online program visitors there. However, tracking data collected during the RCT indicates that only 40% of the participants in the RCT actually visited all of those six pages during their online program exploration. Given that the majority of participants did not visit all the pages on the online program dedicated specifically to teaching it, the results indicating increased ability to describe how to apply interpersonal problem solving skills are even more compelling.

While there has been progress in making academic environments in technical disciplines friendlier for female doctoral students, it remains important for the students to manage discouraging situations in the moment and to anticipate future ones. This study demonstrates how an online learning environment can serve as a resource to expand and reinforce the personal assets of the women. In turn, they should more effectively be able to navigate interactions and solve the aspects of interpersonal problems that are under their control.



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Implications

This research has several important implications for engineering educators. First, this study provided support for the notion that interpersonal problem solving skills can be positively affected through interaction with an online learning environment. The online format of the educational resource under study provides a useful and scalable opportunity to provide relevant learning opportunities to graduate students worldwide. Additionally, the *CareerWISE* online learning environment provides a vehicle for faculty to take advantage of the promising “inverted classroom” technique (e.g., Lage, Platt, and Treglia 2000; Talbet 2012), allowing instruction on effective interpersonal problem solving to take place in a web-based environment outside the class setting, freeing the in-class time for more active learning activities.

The availability of a resource to teach and learn interpersonal problem solving skills also has important implications for teamwork amongst graduate students. Teamwork itself as well as the impact of gender on teamwork are widely acknowledged as important and studied at the undergraduate engineering level (e.g., Ingram and Parker 2002; Loughry, Ohland and Moore 2007; Wolfe and Powell, 2009). Participation on teams that work toward a shared research goal is also a central component of graduate engineering education, however, (Amelink and Creamer 2010; Crede and Borrego 2012) and has been shown to be an important component for succeeding and persisting in graduate school (Rogers and Goktas 2010). Such teams are often made up of members from different disciplines, cultures, and academic levels (Chinowsky and Rojas 2003; Crede and Borrego 2012; McNair et al. 2011). This diversity increases the complexity of team dynamics, underscoring the importance of effective interpersonal problem solving skills (Chinowsky and Rojas 2003; McNair et al. 2011).

The use of open-ended assessments as a method for corroborating evaluation results obtained from self-report scales also provides important evidence for other online learning environment developers who are looking to demonstrate the effectiveness of their instructional materials. As described earlier, the research approach presented here provides different data and a new angle to a full RCT. A recent paper (Bekki, Smith, Bernstein and Harrison 2013) that provided RCT results based only on self-report, ratings-scale generated data, demonstrated the effectiveness of the resource in positively affecting a number of target learning outcomes including coping efficacy and resilience. The self-report data in the 2013 paper showed convincing evidence of the online program’s effectiveness, and many evaluation studies would have stopped at this point. However, the use of the skill-based, open-ended assessment detailed here provides a different type of support for the online program based on a direct measure of learning. While the resources required to administer such an assessment are clearly higher than would be necessary for a standard rating-scale-based (e.g., Likert) assessment, confidence in the results from an assessment like the APSS should be higher, particularly when the measured learning objectives include skill-based concepts.



Limitations and Future Work

As with any study, this one is not without limitations. First, we note the assessments used in this study, while providing a meaningful check on whether participants know how to apply interpersonal problem solving, do not evaluate whether the skills are transferable. The findings are limited by the fact that results are based on participant responses to only a single scenario on one occasion of assessment, which took place immediately following interaction with the intervention. To secure a more extensive evaluation of whether participants maintained the skills, results from a far post-assessment would be required, at minimum. The APSS also does not evaluate whether participants are actually able to enact interpersonal problem solving skills in their own real life settings. Such an assessment would require observations of in situ interpersonal interactions, which would be unlikely to tap the kinds of difficult situations that happen to graduate students at unexpected moments. Moreover, although the APSS and associated rubrics could potentially be useful to other researchers and educators for measuring interpersonal problem solving skills, a significant time commitment would be required to train and engage scorers in the use of the rubrics.

We acknowledge as well that some bias may be present in the findings as a result of the 43 participants who began, but did not complete, the study protocol. While no significant demographic differences were identifiable between the 19 participants who dropped out of the study after beginning it and those who completed, the conclusions may be limited to populations who are more motivated to engage with the content. Finally, the examples included in the online program itself are intentionally designed to appeal to female and research-active doctoral students in STEM fields. As such, additional research would be required to determine whether members of other communities (e.g., undergraduate or male doctoral students in engineering) find the content useful and relevant to their own experiences.

Future work will include alternative assessments of the intervention's effectiveness such as follow-up studies with participants to better understand how they use the interpersonal problem solving knowledge gained from the online program. While such data would still be one step removed from an actual observation-based study, it would provide a self-reported indication of the transferability of skills learned from interaction with the online program to the actual environment of the target audience. Additionally, data mining approaches will be used to better understand how RCT participants' trajectories through the online learning environment (e.g., in what order participants visited various pages within the online program, and for how long they were on each page) are related to their resultant learning. We anticipate this analysis will yield a better understanding of how individual content modules within the online program are related to the acquisition of interpersonal problem solving skills, and we will seek to identify differences in online program exploration patterns between participants who had high (vs. lower) scores on the APSS. Such analyses will provide a more nuanced understanding of *how*



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participants obtained interpersonal problem solving skills (vs. the higher level question addressed in this study of *whether* they learned them). Finally, further research is planned to understand whether and how elements of perceived tangible support or external barriers in the participant's proximal environment (e.g., characteristics of degree programs, relationship with advisor, consideration of home life, etc.) are related to learning of interpersonal problem solving skills.

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REFERENCES

- Allen, E.I., and J. Seaman. 2013. *Changing course: Ten years of tracking online education in the United States*. Babson Survey Research Group and Quahog Research Group, LLC.
- Amelink, C. T., and E.G. Creamer. 2010. "Gender differences in elements of the undergraduate experience that influence satisfaction with engineering major and the intent to pursue engineering as a career." *Journal of Engineering Education* no. 99(4): 81-92.
- Ampaw, F. D., and A.J. Jaeger. 2012. "Completing the three stages of doctoral education: An event history analysis." *Research in Higher Education* no. 53: 640-660.
- Anderson-Rowland, M.R., B.L. Bernstein, and N.F. Russo. 2007. "Encouragers and discouragers for domestic and international women in doctoral programs in engineering and computer science." In *Proceedings of the 2007 American Society for Engineering Education Conference*.
- Arlin, M. 1976. "Casual priority of social desirability over self-concept: A cross-lagged correlation analysis." *Journal of Personality and Social Psychology* no. 33(3): 267-272.
- Bancino, R., and C. Zevalkink. 2007. "Soft skills: The new learning environment for hard-core technical professionals." *Techniques: Connecting Education and Careers* no. 82(5): 20-22.
- Bandura, A. 1986. *Social Foundations of Thought and Action: A Social Cognitive Theory*. New Jersey: Prentice Hall.
- Bandura, A. 1997. "Self-efficacy: toward a unifying theory of behavioral change." *Psychological Review* no. 84(2): 191-215.
- Beck, A.T. 1983. "Cognitive approaches to stress reactions" In *Clinical Guide to Stress Management*, edited by P. Lehrer and R. Woolfolk. New York: Guilford Press.
- Bekki, J.M., B.L. Bernstin, K. Ellison, A. Sridharan, L. Hit, and Q. Spadola. 2008. "Work in progress: Using case studies to increase the retention of female doctoral students in STEM fields." In *Proceedings of the 38th ASEE/IEEE Frontiers in Education Conference*.



Bekki, J.M., M.L. Smith, B.L. Bernstein, and C.J. Harrison, C.J. 2013. "Effects of an online personal resilience training program for women in STEM doctoral programs." *Journal of Women and Minorities in Science and Engineering*, no. 19(1): 17-35.

Bernstein, B. L. 2011. "Managing barriers and building supports in science and engineering doctoral programs: Conceptual underpinnings for a new online training program for Women." *Journal of Women and Minorities in Science and Engineering* no. 17(1): 29-50.

Bernstein, B.L. and N.F. Russo. 2008. "Explaining too few women in academic science and engineering careers: A psychosocial perspective." In M. *The Psychology of Women at Work: Challenges and Solutions for Our Female Workforce*, Volume 2, edited by M. Paludi. Westport, CT: Praeger Press.

Bloom, B.S. 1956. *A Taxonomy of Educational Objectives: Handbook I, The Cognitive Domain*. New York: Longman.

Brown, G. T. L., K. Glasswell, and D. Harland. 2004. "Accuracy in the scoring of writing: Studies of reliability and validity using a New Zealand writing assessment system." *Assessing Writing* no. 9: 105-121.

Campbell, J. C., J. Hays, M. Core, M. Birch, M. Bosack, and R.E. Clark. 2011. "Interpersonal and leadership skills: Using virtual humans to teach new officers." In *Proceedings of the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC)*.

Carver, C.S., M.F. Scheier, and J.K. Weintraub. 1989. "Assessing coping strategies: A theoretically based approach." *Journal of Personality and Social Psychology* no. 56(2): 267-283.

Chinowsky, P.S., and E.M. Rojas, E.M. 2003. "Virtual teams: Guide to successful Implementation." *Journal of Management in Engineering* no. 19(3): 98-106.

Clough, G. W. 2004. *The Engineer of 2020: Visions of Engineering in the New Century*. Washington: National Academy of Engineering.

Cohen, J. 1988. *Statistical Power Analysis for the Behavioral Sciences*. New Jersey: Lawrence Erlbaum Associates.

Council of Graduate Schools (CGS). 2008. Ph.D. Completion and Attrition: Analysis of Baseline Demographic Data from the Ph.D. Completion Project. Washington, DC: Council of Graduate Schools.

Crede, E., and M. Borrego. (2012). "Learning in graduate engineering research groups of various sizes." *Journal of Engineering Education* no. 101 (3): 565-589.

Crooks, T.J. 1988. "The impact of classroom evaluation practices on students." *Review of Educational Research* no. 58 (4): 438 - 481.

Deek, F. P., S.R. Hiltz, H. Kimmel, and N. Rotter. 1999. "Cognitive assessment of students' problem solving and program development skills." *Journal of Engineering Education* no. 88: 317-326.

Dochy, F., M. Segers, P. Van den Bossche, and D. Gijbels. 2003. "Effects of problem-based learning: A meta-analysis." *Learning and Instruction* no. 13(5): 533-568.

D'Zurilla, T.J. and A.M. Nezu. 2008. *Problem-Solving Therapy: A Positive Approach to Clinical Intervention, 3rd Edition*. New York: Springer.

D'Zurilla, T. J., and M.R. Goldfried. 1971. "Problem- solving and behavior modification." *Journal of Abnormal Psychology* no. 78:107-126.

Etzkowitz, H., C. Kemelgor, and B. Uzzi. 2000. *Athena Unbound: The Advancement of Women in Science and Technology*. Cambridge: Cambridge University Press.

Fox, M.F. 2001. "Women, science, and academia: graduate education and careers." *Gender & Society* no. 15(5): 654-666.

Gijbels, D., F. Dochy, P. Van den Bossche, and M. Segers. 2005. "Effects of problem-based learning: A meta-analysis from the angle of assessment." *Review of Educational Research* no. 75(1): 27-61.

Goh, S.M. 2012. "Star Power for teaching professional skills to engineering students." *Advances in Engineering Education*, accessed August, 2013, from <http://advances.asee.org/vol03/issue01/papers/aee-vol03-issue01-p03.pdf>.



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- Hackett, G. and N.E. Betz. 1981. "A self-efficacy approach to the career development of women." *Journal of Vocational Behavior* no. 18(3): 326-339.
- Hayes, A., and K. Krippendorff. 2007. "Answering the call for a standard reliability measure for coding data." *Communication Methods and Measures* no. 1(1): 77-89.
- Ingram, S., and A. Parker. 2002. "Gender and modes of collaboration in an engineering classroom: A profile of two women on student teams." *Journal of Business and Technical Communication*. no. 16(1): 33-68.
- Johnson, W.L. 2010. "Using immersive simulations to develop intercultural competence." In *Culture and Computing*. Berlin: Springer J Verlag.
- Jonsson, A. and G. Svingby. 2007. "The use of scoring rubrics: Reliability, validity and educational consequences." *Educational Research Review* no. 2: 130-144.
- Joyner, F. F., D.T.Y. Mann, and T. Harris. 2012. "Engineering as a social activity: Preparing engineers to thrive in the changing world of work." *American Journal of Engineering Education* no. 3(1): 67-82.
- Kass, A., R. Burke, E. Blevis, and M. Williamson. 1994. "Constructing learning environments for complex social skills." *The Journal of the Learning Sciences* no. 3 (4): 387-427.
- Katz, I. R., N. Elliot, Y. Attali, D. Scharf, D. Powers, H. Huey, and V. Briller. 2008. *The Assessment of Information Literacy: A Case Study*. ETS Research Report No. RR-08-03. Princeton, NJ: Educational Testing Service.
- Kranov, A.A., C. Hauser, R. Olsen, and L. Girardeau. 2008. "A direct method for teaching and assessing professional skills in engineering programs." In *Proceedings of the American Society for Engineering Education Annual Conference*.
- Krippendorff, K. 2004. *Content Analysis: An Introduction to Its Methodology, Second Edition*. California: Sage Publications.
- Lage, M.J., G.J. Platt, and M. Treglia. 2000. "Inverting the classroom: a gateway to creating an inclusive learning environment." *Journal of Economic Education* no. 4: 30-43.
- Lazarus, R.S. and S. Folkman. 1984. *Stress, Appraisal and Coping*. New York: Springer.
- Lent, R.W., S.D. Brown, and G. Hackett. 1994. "Toward a unifying social cognitive theory of career and academic interest, choice, and performance." *Journal of Vocational Behavior* no. 45(1): 79-123.
- Lent, R.W., S.D. Brown, and G. Hackett. 2000. "Contextual supports and barriers to career choice: A social cognitive analysis." *Journal of Counseling Psychology* no. 47(1): 36-49.
- Liberatore, M.W., C.R. Vestal, and A.M. Herring. 2012. "YouTube Fridays: Student led development of engineering estimate problems." *Advances in Engineering Education*, accessed August, 2013, from <http://advances.asee.org/vol03/issue01/papers/aee-vol03-issue01-p02.pdf>.
- Lott, J. L., S. Gardner, and D.A. Powers. 2009. "Doctoral student attrition in the STEM fields: An exploratory event history analysis." *Journal of College Student Retention: Research, Theory and Practice* no. 11(2): 247-266.
- Loughry, M. L., M. W. Ohland, and D. D. Moore. 2007. "Development of a theory-based assessment of team member effectiveness." *Educational and Psychological Measurement* no. 67(3): 505-524.
- Maddi, S.R. 2005. "On hardiness and other pathways to resilience." *American Psychologist* no. 60(3): 261-262.
- Masten, A. S. 2001. "Ordinary magic: Resilience processes in development." *American Psychologist* no. 56(3): 227-238.
- Matusovich, H., M. Paretti, K. J. Cross, and A. Motto. 2012. "Teaching teamwork and communication in engineering: Strategies and Opportunities." In *Professional Communication Conference (IPCC), 2012 IEEE International*, pp. 1-4.
- McMartin, F., A. McKenna, and K. Youssefi. 2000. "Scenario assignments as assessment tools for undergraduate engineering education." *IEEE Transactions on Education* no. 43 (2): 111-119.
- McNair, L.D., C. Newswander, D. Boden, and M. Borrego. 2011. "Student and faculty interdisciplinary identities in self-managed teams." *Journal of Engineering Education* no. 100 (2): 374-396.



- Means, B., Y. Toyama, R. Murphy, M. Bakia, and K. Jones. 2010. *Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies*. Washington DC: US Department of Education.
- Mohan, A., D. Merle, C. Jackson, J. Lannin, and S.S. Nair. 2010. "Professional skills in the engineering learning environment." *IEEE Transactions on Education* no. 53(4): 562-571.
- Moskal, B.M., J.A. Leydens, and M.J. Pavelich. 2002. "Validity, reliability and the assessment of engineering education." *Journal of Engineering Education* no. 91(3): 351-354.
- Moreno, R., G. Ozogul, and M. Reisslein. 2011. "Teaching with concrete and abstract visual representations: Effects on students' problem solving, problem representations, and learning perceptions." *Journal of Educational Psychology* no. 103(1): 32-47.
- National Research Council. 2007. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, DC: National Academies Press.
- National Science Foundation, Division of Science Resources Statistics. 2004. *Women, Minorities, and Persons with Disabilities in Science and Engineering*, accessed 05/08/2013, from http://www.nsf.gov/statistics/wmpd/archives/wmpd_2004.zip.
- National Science Foundation, Division of Science Resources Statistics. 2010. *Graduate Students and Postdoctorates in Science and Engineering: Fall, 2007*, accessed 05/08/2013, from <http://www.nsf.gov/statistics/nsf10307/pdf/nsf10307.pdf>.
- National Science Foundation, Division of Science Resource Statistics. 2011. *Survey of Earned Doctorates*. Arlington, VA: National Science Foundation
- Narciss, S., A. Proske, and H. Koerndle. 2007. "Promoting self-regulated learning in web-based environments". *Computers in Human Behavior* no. 23: 1126-1144.
- Perkins, K., W. Adams, M. Dubson, N. Finkelstein, S. Reid, C. Wieman, and R. LeMaster. 2006. "PhET: Interactive simulations for teaching and learning physics." *The Physics Teacher*, no. 44: 18-23.
- Preston, A.E. 2004. *Leaving Science: Occupational Exit from Science Careers*. New York: Russel Sage Foundation.
- Pretzer, J.L. and A.T. Beck. 2007. "Cognitive approaches to stress and stress management." In *Principles and Practices of Stress Management, 3rd edition*, edited by P.M. Lehrer, R.L. Woolfolk and W.E. Sime. New York: Guilford, pp. 465-496.
- Rogers, S.W. and R.K. Goktas. 2010. "Exploring engineering graduate student research proficiency with student surveys." *Journal of Engineering Education* no. 9(3): 263-278.
- Rosser, S.V. 2004. *The Science Glass Ceiling: Academic Women Scientists and the Struggle to Succeed*. New York: Routledge.
- Rosser, S.V. 2012. *Breaking into the Lab: Engineering Progress for Women in Science*. New York: New York University Press.
- Sankar, C., V. Varma, and P. Raju. 2008. "Use of case studies in engineering education: Assessment of changes in cognitive skills". *Journal of Professional Issues in Engineering Education and Practice* no. 134 (3): 287-296.
- Settles, I.H., L.M. Cortina, J. Malley, and A.J. Stewart. 2006. "The climate for women in academic science: The good, the bad, and the changeable." *Psychology of Women Quarterly* no. 30(1): 47-58.
- Seymour, E., and N.M. Hewitt. 1997. *Talking About Leaving: Why Undergraduates leave the Sciences*. Boulder, CO: Westview.
- Shuman, L. J., M. Besterfield-Sacre, and J. McGourty. 2005. "The ABET 'professional skills'- Can they be taught? Can they be assessed?" *Journal of Engineering Education* no. 94(1): 41-55.
- Sonnert, G. and G. Holton, G. 1995. *Who Succeeds in Science?: The Gender Dimension*. New Brunswick, NJ: Rutgers University Press.
- Steif, P. S., J.M. Lobue, L.B. Kara, and A.L. Fay. 2010. "Improving problem solving performance by inducing talk about salient problem features." *Journal of Engineering Education* no. 99(2): 135-142.
- Stemler, S.E. 2004. "A comparison of consensus, consistency, and measurement approaches to estimating interrater reliability." *Practical Assessment, Research and Evaluation* no. 9(4), accessed May 25, 2012, from <http://PAREonline.net/getvn.asp?v=9&idn=4>.



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Talbet, R. 2012. "Inverted classroom." *Colleagues* no. 9(1), retrieved June, 2012, from <http://scholarworks.gvsu.edu/colleagues/vol9/iss1/7>.

Tonso, K.L. 2006. "Teams that work: Campus culture, engineer identity, and social interactions." *Journal of Engineering Education* no. 95(1): 25-37.

Tsaushu, M., T. Tal, O. Sagy, Y. Kali, S. Gepstein, and D. Zilberstein. 2012. "Peer learning and support of technology in an undergraduate biology course to enhance deep learning." *Life Sciences Education* no. 11(4): 402-412.

U.S. Department of Education (2009), "Identifying and Implementing Educational Practices Supported By Rigorous Evidence: A User Friendly Guide," retrieved January, 2014 from http://www.ed.gov/rschstat/research/pubs/rigorousetid/guide_pg5.html.

Valian, V. 1998. *Why So Slow: Advancement of Women*. Boston, MA: MIT Press.

Valian, V. 2007. "Women at the top in science—And elsewhere." In *Why Aren't More Women in Science? Top Researchers Debate the Evidence*, edited by S.J. Ceci and W.W. Williams. Washington, DC: American Psychological Association.

Wao, H.O., R.S. Lee. and K.M. Borman. 2010. "Climate for retention to graduation: A mixed methods investigation of student perceptions of engineering departments and programs." *Journal of Women and Minorities in Science and Engineering* no. 16(4): 293-318.

Wang, Y., and V. Chiew. 2010. "On the cognitive process of human problem solving." *Cognitive Systems Research*. no. 11(1), 81-92.

Wieman, C. E., W.K. Adams, and K.K. Perkins. 2008. "PhET: Simulations that enhance learning." *Science* no. 322: 682-683.

Wiggins, G. P. 1993. *Assessing Student Performance*. San Francisco: Jossey-Bass Publishers.

Wolfe, J., and E. Powell. 2009. "Biases in interpersonal communication: How engineering students perceive gender typical speech acts in teamwork." *Journal of Engineering Education*. no. 98(1): 5-16.

Xie, Y. and K.A. Shauman. 2003. *Women in Science: Career Processes and Outcomes*. Cambridge, MA: Harvard University Press.

Zbylut, M. L., K.A. Metcalf, J.M. Kim, R.W. Hill, Sc. Rocher, and C. Vowels. 2007. "Army excellence in leadership (AXL): A multimedia approach to building tacit knowledge and cultural reasoning." *Technical Report 1194*. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, retrieved January, 2014 <http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA461995>.

Zbylut, M. L. and J.N. Ward, J. N. 2005. "Developing interpersonal abilities with interactive vignettes." In *Proceedings for the Army Science Conference*.

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